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PATENT OFFICE
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Department of Industrial Policy and Promotion

It is hereby certified that annexed here to is a true copy of **Application, Provisional Specification & Abstract** of the patent application as filed and detailed below:-

Date of application	:	**15-12-2003**
Application No	:	**1014/CHE/2003**
Applicants	:	**M/s. Matrixview Pte Ltd, 9, Shenton Way #05-02, Singapore 068813.**

In witness there of
I have here unto set my hand

Dated this the 18th day of March 2005
27th day of Phalguna, 1926(Saka)

By Authority of
THE CONTROLLER GENERAL OF PATENTS, DESIGNS AND TRADE MARKS.

M. S. V

(M.S.VENKATARAMAN)
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CBR: 7135

1014/CHE/03

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15/XII

FORM 1

The Patents Act 1970
(39 of 1970)

GOVT. OF INDIA 011808 15 DEC 2003 PATENT OFFICE (BR.) CHENNAI

APPLICATION FOR GRANT OF A PATENT
(See sec.5 (2), 7, 54 and 135 and Rule 33A)

1014/CHE/2003
15.12.2003

Matrixview Pte Ltd
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Singapore 068813
Tel: (65) 6336 2777

1014/CHE/2003

1014 DEC 2003

Cont. P2

15/12/2003

New Appl.

15/XII/03

ORIGINAL 1014/CHE/2003

1. Hereby declare –
   (a) That we are in possession of an invention titled **"NOVEL ALGORITHM FOR LOSSLESS DATA COMPRESSION"**

   (b) That the Provisional Specification relating to this invention is filed with this application.

   (c) That there is no lawful ground of objection to the grant of a patent to us.

2. Further declare that the inventor for the said invention is,

   Arvind Thiagarajan
   H 24/6, Vaigai Street, Besant Nagar
   Chennai 600090. Nationality - Indian

3. We, claim the priority from the application(s) field in convention countries, particulars of which are as follows:-

   Not applicable

4. We state that the said invention is an improvement in or modification of the invention, the particulars of which are as follows and of which we are the applicant/patentee:

   Not applicable

5. We state that the application is divided out of our application, the particulars of which are given below and pray that is application deemed to have been filed on _______________ under section 16 of the act.

   Not applicable

6. That we are the assignee of the true and first inventor.

   Not applicable

7. That our address for service in India is as follows:

   Matrix View Technologies (India) Private Limited
   No.69, Mahalakshmi Koil Sreet
   Kalakshetra Colony, Besant Nagar
   Chennai 600090. TAMILNADU. INDIA.

8. Following declaration was given by the inventor or applicant in the convention country declare that the applicant herein is our assignee or legal representative

   Not applicable

9. That to the best of my knowledge, information and belief the facts and matters stated herein the correct and that there is no lawful ground of objection to the grant of patent to us on this application.

T. Arvind

Mr. Arvind Thiagarajan
(Inventor)

10. Following are the attachment with the application:

    a) Provisional specification (3 copies)
    b) Fee of Rs.

I request that a patent may be granted to us for the said invention

Dated at Chennai on this 11th day of December, 2003

Anand T.

Mr. Anand Thyagarajan
(Authorized Signatory)

To

The Controller of Patents
The Patent Office
At Chennai

1014/CHE/2003

ORIGINAL

1014/CHE/2003 5 DEC 2003

FORM 2

The Patents Act, 1970

Provisional Specification

Section 10

"NOVEL ALGORITHM FOR LOSSLESS DATA COMPRESSION"

Applicant:

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TAMILNADU. INDIA.

The following Provisional Specification describes the nature of the invention and the manner in which it is to be performed.

Field of Invention

The present invention relates to the compression of image or other highly correlated data streams

Background of Invention

The role of data and image compression assumes significant importance as the world makes a paradigm shift from analog to digital systems. Data compression, which was impossible due to the inherent disadvantages of the analog systems, has become a feasible reality with digital systems. The computational overheads and the complexity posed the most serious threat to the development data compression. With the advent of high-speed digital processors with MIPS capability most of these problems have been overcome.

Image compression has many practical applications, which are driven by the fact that image data is a highly correlated data stream. Image compression can be either lossy or lossless depending on the criticality and nature of the application. The human eye is more sensitive to changes in luminance than to changes in color. Hence for applications that are not critical in nature i.e. in cases where the quality of the compressed data is not an important factor for further processing lossy compression can be employed. The portions of the image data that do not produce a perceptible visual difference are removed resulting in excellent compression ratios. There are applications where image distortion is totally unacceptable, which require only lossless compression, where portions of image cannot be removed no matter how inconsequential the data is, resulting in very low compression ratios. An

ideal solution to this problem will be a lossless compression technique that produces significant compression ratios, which is exactly the motivation behind this novel and unique invention.

Data Compression Principles

All the data compression techniques are based on the fundamental principle of Shannon's Information theory, which says that there is a limit to the number of bits required to code a unique symbol, called entropy, given by

$$\mathbf{H = - p_i \log_2 p_i}$$

where p_i is the probability of occurrence of the symbol. The implication of this equation is that if a symbol occurs many times, i.e. the frequency of occurrence is high then this symbol contributes to redundancy and is hence given lesser priority when compared to a symbol whose frequency of occurrence is much lesser. This forms the basis for all the entropy coding or source coding schemes. The idea is to give a shorter codeword to more probable events i.e. the more frequently the symbol occurs, the SHORTER it's codeword is. Image data follows a Laplacian distribution, which means that the occurrence of each symbol is equiprobable. Hence all the symbols require almost the same number of bits resulting in very low compression ratios. To achieve high compression ratios we should transform the image data stream in a manner where the even probability distribution in the original image is transformed to a probability distribution that has a few symbols having a high frequency of occurrence the other symbols a relatively low frequency

of occurrence, resulting in a significant reduction in the bits per symbol, thereby enhancing the compression ratios.

Some of the popular entropy encoders are Run Length Encoder, Huffman, Shannon Fano, Limpel–Ziv, Arithmetic Encoder etc. All the encoding techniques with the exception of the arithmetic encoder allot a minimum of atleast one bit per symbol. The arithmetic encoder, whose unique algorithm generates a real number for a given sequence of symbols, can theoretically achieve bit rates of less than one bit per symbol.

Current Image Compression Technologies

Image compression technologies can be broadly classified as either Lossy or lossless. An image compression technology can be classified as Lossy or Lossless depending on whether the subsequent decompression of the compressed data produces an exact pixel-to-pixel replica of the original data or not.

We can logically infer from the section on Data Compression Principles that any efficient compression technique requires a transformation also known as pre – coding, which in turn aids in increasing the efficiency of the second step, the entropy coder. At this stage it must be emphasized that if the entropy coder has to produce good compression ratios then the pre – coding should transform the data into a form suitable for the entropy code. If the transformation is not efficient enough then the entropy coder is rendered redundant. Hence it can be logically concluded that the pre-coding or the transformation is the most important stage of any image compression algorithm.

The most popular pre–coding transformation used in image compression is the Discrete Cosine Transform (DCT). This transformation gives the frequency and extent of data change inside the image. Another important property of any transformation is that it should be reversible too, so that the reverse process can be applied at the decompression stage to obtain the original image. This transformation is extensively used in the JPEG algorithms and its variants.

As indicated above DCT is a reversible transform whose forward transform is given as

$$DCT(i,j) = \frac{1}{\sqrt{2N}} C(i)C(j) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} f(x,y) \cos\left[\frac{(2x+1)i\pi}{2N}\right] \cos\left[\frac{(2y+1)j\pi}{2N}\right]$$

where $C(x) = \frac{1}{\sqrt{2}}$ if $x = 0$, else 1 if $x > 0$.

DCT(i, j) = C(i).C(j). Σ Σ f(x,y).......

The above-mentioned technique poses the following problems

The complexity of the equation in terms of the number of multiplications and additions, The most straightforward way to implement the DCT is to use the defining Equation In the 2D case, with arrays of dimensions $N \times N$, the number of multiplications is on the order of $2N^3$ using a separable approach of computing 1D row and column DCT's. Specifically, for an 8 × 8 pixel array, which is used in the JPEG family which has 1024 multiplications and 896 additions. In spite of the tremendous improvement made in terms of reducing the number of computations, the reduction has not been significant enough to reduce the tremendous overhead it places on the hardware that implements the algorithm.

Even though the image data is an integer, their multiplication to cosine terms in the formula produces fractional numbers or real numbers because cosine values are fractional in nature until and unless the integer is in multiples of Pi, which might not be the case. Since fractional numbers need infinite precision to store them exactly, they might produce errors in the reverse process resulting in losses, which mean that they are no longer pixel to pixel lossless.

Another popular transformation used is called the wavelet transform, which is used in the latest image compression techniques like JPEG2000. This uses a mother wavelet to decompose the image data into frequency sub - bands, which in turn increases the redundancy in most of the sub – bands hence improving compression ratios. Used in their original form the mother wavelets do not give integer-to-integer transformation but when used after a process called lifting they become integer-to-integer transforms thereby making the entire process lossless.

Color Transformations also offer an interesting prospect to compression. Commonly used color space is RGB where every pixel is quantized by using a combination of Red, Green and Blue (Primary Colors) values. This format is ideally suited for designers but no so ideal for a compression algorithm. As indicated in the human eye is more sensitive to luminance than color hence Chrominance Luminance and Value format offers an interesting perspective to compression.

Description

Image data is highly correlated i.e., adjacent pixels are closely related. Hence it is possible to create a significant redundancy, which is then followed by a unique

combination of existing data transforms and source encoders to achieve higher compression ratios.

Repetition Coded Compression provides a unique solution where in we can achieve higher compression ratios without having to make a compromise in quality. This essentially means that Repetition Coded Compression can achieve very high compression ratios maintaining the pixel-to-pixel integrity of the image data during the compression and decompression process. Repetition Coded Compression is an algorithm that exploits the close correlation between adjacent pixels.

Repetition Coded Compression divides the Pre Coding block of the compression process into two logical stages, the transformation and the data – rearrangement stage. This transformed and re–arranged data is passed as an input to the source coder, which comprises of an arithmetic coder preceded by a Run length encoder. Repetition Coded Compression 's transformation primarily has four variants

- Repetition Coded Compression Horizontal
- Repetition Coded Compression Vertical
- Repetition Coded Compression Predict
- Repetition Coded Compression Multidimensional

Repetition Coded Compression Horizontal, Repetition Coded Compression Vertical and Repetition Coded Compression Predict can also be classified as 1 – D Repetition Coded Compression category and Repetition Coded Compression Multidimensional can be classified 2 – D Repetition Coded Compression category.

The data re – arranging stage of Repetition Coded Compression comprises of the following steps

- Reversible – Sort process
- Last to First re-arrangement

Applications of the Present Invention

Repetition Coded Compression can be used in a wide gamut of applications ranging from Medical Imaging to Digital Entertainment to Document management. Each of these verticals requires Repetition Coded Compression to be implemented in its own unique way to deliver a robust and powerful end product.

Repetition Coded Compression could be deployed in the following forms for commercialization.

1. Chip – (ASIC, FPGA etc.)
2. DSP, Embedded Systems
3. Standalone Hardware boxes
4. Licensable Software (as DLL's OCX etc.)
5. Software deliverables

Thus, the above mentioned account describes the invention in detail. It is intended that the foregoing description is only illustrative of the present invention and it is not intended that this unique invention be limited or restricted thereto.

Many specific embodiments of this novel invention will be apparent to one, skilled in the art from the foregoing disclosure. The scope of the invention should be determined not only with reference to the above description but to all other additions, substitutions & modification of the present invention without departing from the spirit of this invention.

Abstract

This invention is a process for compressing highly correlated image data in an absolutely lossless manner (i.e. pixel to pixel lossless with zero Means Square Error M.S.E). The system for compressing image and other highly correlated data comprises means for reshaping the data, means for encoding the repetitions and means for storing the compressed data.

The process of reshaping the image data includes a lossless transformation followed by data re –arrangement. The lossless transformation is performed on an image data set called pixels, which is transformed into bit – planes and data values, using one of the four data transformation algorithms Repetition Coded Compression Horizontal, Vertical, Predict and Multi – dimensional. Repetition Coded Compression involves is an integer-to-integer transformation that converts the integer value of a pixel into another set of integer values to create redundancy. This integer to integer transformation is absolutely loss less as there is no loss of pixel data unlike other algorithms like JPEG that utilize integer to floating point transformations. The floating-point number cannot be accurately stored and hence there is a loss of data.

Repetition Coded Compression uses simple logical operations to increase the redundancy in the image. As there is no multiplication or division process in Repetition Coded Compression, the image attributes are preserved without any loss. Thus the simple transformation works at increasing the redundancy.

The next process is the re-arrangement of the transformed pixels. This process further increases redundancy by sorting and rearranging the data in a suitable manner.

The redundancy thus created is then passed on to an entropy coder that allocates specific codes to the data. The entropy process gives shorter codes to the more frequently occurring symbols i.e. the more frequently the symbol occurs, the shorter the code. Huffman or arithmetic coding effectively compresses the redundancy created by Repetition Coded Compression. The encoding maintains the loss less property of the image and at the same time producing very good compression ratios.